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THE ORIGIN OF SPECIES IN NATURE[1]

DR. HENRI HUS
MISSOURI BOTANICAL GARDEN
UNIVERSITY OF MICHIGAN

AMONG the duties of the botanist is that of adding to the number of known species, varieties and forms. To reach this end several ways are open. One may, by studying the flora of new or insufficiently explored areas, not only extend the range of species formerly known, but add new species. The work of Setchell and his students, especially Gardner, done on the algal flora of the Pacific Coast, yields an excellent illustration.[2]

Sometimes it is possible to correlate with such investigations work of economic value. The results obtained by agricultural explorers working under the auspices of the Office of Foreign Seed and Plant Introduction of the Bureau of Plant Industry, U. S. Dept. of Agriculture and other[3] institutions, offer a case in point. Such work, to lead to the desired result, requires men of especial fitness, physical, moral and mental. Not only must they possess physical endurance to overcome the hardships with which they necessarily meet. Moral courage, moral strength are necessary to extricate them from the many difficult positions in which they are bound to find themselves and to bring to a successful end the undertaking upon which they have embarked. Further, a thorough knowledge and an excellent judgment are essential. Yet none of these are sufficient unless they be complemented by an all-pervading love for the subject, a devotion which counts all obstacles as naught and persists in the face of difficulties which to most men would appear unsurmountable. Frank Meyer, agricultural explorer, now, for the second time, exploring eastern Asia—last heard of when entering Thibet—exemplifies this ideal. Such are the men who on their return to the civilized world bring back with them the rare plants which delight the collector and which, in themselves frequently of apparent insignificance, in a few years add immensely to our collections. The discovery of *Nicotiana Forgetiana*[4] is, in recent years, perhaps the most widely known instance through the part played by this species in the introduction to our gardens of *Nicotiana Sanderæ* (*N. alata* × *Forgetiana*). But not always is it necessary to draw on the flora of distant countries. By thoroughly going over a well-covered territory one may be able to add new varieties of a more or less well-known species, such as was the case with *Oxalis stricta viridiflora*,[5] which, since the time of publication of the original paper, has been found near Thomson, Ga.[6] This plant, since the spring of 1909, has established itself in the Ann Arbor experiment garden, spreading rapidly from seed selfsown in the latter part of the same summer. The plants grow in the open as well as in more shaded places and on a light, sandy soil. The varietal character maintains itself perfectly, as it does in the Missouri Botanical Garden, where, on a recent visit, I saw a bed of it, in the open and on a fairly heavy soil. Though there is a certain amount of variation in the intensity of the green coloring of the flower, due to a variation in the relative amounts of chloroplasts and yellow chromoplasts, the plant appears to have undergone a sufficient number of fairly rigid tests, under widely divergent conditions, and for a sufficient number of generations (9), to entitle it to recognition as a distinct, non-pathological variety. The variation in the color of the flower I am inclined to ascribe to differences in light intensity. In a bed, situated in the middle of the experiment garden, *i. e.,* in an open place where no obstruction prevents full and direct illumination, the flowers are uniformly green. When the plants are grown in the greenhouse or in the shade of shrubs, there seems to be a tendency for the flowers to assume a more yellow tinge. But not in a single instance has a flower been observed which possibly could have been mistaken for one of the species.

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[1] Read, through the courtesy of Mr. Henry W. Anderson, before the Academy of Science of St. Louis, May 15, 1911. Contributions from the Botanical Laboratory of the University of Michigan, No. 125.

[2] Univ. Calif. Publ. Bot., 1^3 et seq., 1903–1910.

[3] Hansen, N. E., ''The Wild Alfalfas and Clovers of Siberia, with a Perspective View of the Alfalfas of the World,'' Bull. No. 150, B. P. I., U. S. D. A., 1909.

Aaronsohn, A., ''Agricultural and Botanical Explorations in Palestine,'' Bull. No. 180, B. P. I., U. S. D. A., 1910.

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[4] *Curtis' Botanical Magazine*, 4th Ser., **1**, pl. 8006, 1905.

[5] Hus, H., "Virescence of *Oxalis stricta*," Ann. Rep. Missouri Bot. Gard., **18**: 99, pl. 10, 11, 1907.

[6] Bartlett, H. H., "On *Oxalis stricta viridiflora*," *Rhodora*, **11**: 118, June, 1909.

Again it may be that a form deserving specific rank is discovered, as instanced by the now well-known *Capsella Heegeri.*[7] Such discoveries possess an added charm since in these cases the possibility of a recent origin of the new form is not excluded. Sometimes it is possible to prove this experimentally, as was done by de Vries for his evening primroses. An illustration of probably recent origin and of repetition of mutation is yielded by the discovery of a single specimen of the *inermis* variety of *Cynara Carduncululs* in Algiers by Trabut.[8] But some years ago what would seem to have been the same variety was grown in the St. Louis experiment garden from seed which my father kindly obtained for me from the then director of the Botanical Garden at Buenos Aires and the ancestry of which I understand was to be traced to an individual growing wild in the vicinity.[9]

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[7] Solms-Laubach, H. zu, "Cruciferenstudien—I, *Capsella heegeri,* eine neuentstandene Form der deutschen Flora," *Bot. Zeit.,* **55**: 167, pl. 7, 1900.

[8] Trabut, L., "Sur une mutation inerme du *Cynara Carduncululs,*" *Bull. Soc. Bot. Fr.,* **57**: 350, 1910.

[9] *Cynara Carduncululs,* a native of the Mediterranean region, emigrated to South America, where it occupies large areas (Darwin, "Animals and Plants under Domestication"). An analogous case is that of *Silybum Marianum,* likewise a native of the Mediterranean region and now largely

Generally speaking, the investigation of the flora of a newly discovered or formerly inaccessible region is a matter of choice or, better, perhaps, opportunity. The same is true for the detailed study of our collective species, leading to a recognition of component elements as illustrated by the work of Small on *Oxalis*,[10] *Rhus*, etc. Whoever can devote a part of his time to the study of a genus is able to establish the existence of differences which, formerly ignored and in themselves slight, are of the greatest importance for the tracing of relationships. Unfortunately, perhaps, in such studies there is usually developed a mass of detail so great, so intricate that none but a few specialists are able to recognize the various forms. *Hieracium, Aster, Cyperus* are names sufficient to strike terror in the hearts of any but the most ardent systematists. But before such a detailed study can be made there must be gathered, in the first place, herbarium material. It is not sufficient to possess a single specimen. Material must be collected from various habitats and both during the flowering and fruiting periods. Often there are differences between the leaves of old and young shoots, as in *Cratægus*. Or the leaves of the fruiting branches may be different from those of purely vegetative shoots as in *Hedera Helix*. *Ficus* and *Pothos* both may show leaves of a very different character.[11] None would at first sight believe leaves of seedlings or of adventitious shoots of *Eucalyptus globulus* and those of older specimens to belong to the same species. Many species of *Acacia* show, during the first few years of their existence, well-developed phyllodes which later disappear entirely. Sometimes even the leaves on the same

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naturalized in California where it forms a common and, on account of its leaves, a most conspicuous weed.

[10] "North American Flora," **25**^{1}: 25, 1907.

[11] In the greenhouses of the Missouri Botanical Garden may be seen a very fine specimen of *Ficus repens* which near the ground and up to a height of some eight feet, produces the small leaves typical of this species. When, however, the plant makes a bend to twine horizontally along a rod, large leaves are produced. Other instances are given in de Vries's "Species and Varieties," Ch. 15.

shoot may present a very different appearance. And while this is something not entirely unexpected in hybrids as in *Quercus Leana* (*Q. coccinea*×*imbricaria*) and Boston fern hybrids, it is a source of astonishment when this occurs in species which we do not believe to be of hybrid origin. Heterophylly is a matter of common observation in the ubiquitous horseradish, *Radicula Armoracia*. *Sterculia diversifolia*, commonly cultivated in greenhouses, has leaves which are mostly ovate to lanceolate in outline and which are often entire or variously three- to five-lobed on the same shoot. The sassafras, *S. variifolium*, illustrates the same principle, in fact, derives its name from this feature. The paper mulberry, *Broussonetia papyrifera*, shares the irregular lobing of the leaf with its near relatives, *Morus rubra* and *M. alba*.[12] The cut-leaved Persian lilac is very variable in this respect.[13] Sometimes seasonal differences are so great as to make collecting throughout the year an absolute necessity,[14] an instance so strikingly illustrated by *Viola palmata*. In woody plants there is not infrequently a return to the nepionic stage in the leaves produced near the base.[15] When we remember that heterochromatism[16] may add a further complication, it becomes evident that it is not sufficient to be able to refer to herbarium specimens only. The living plant must be studied in its various stages of development. It is by this means only that one may arrive at a true estimate of the stability and significance of minute details.

[12] Rep. Bot. Dep. New Jersey Agric. Coll. Exp. St., 325, pl. 21, 1909. Fry, A., "Note on Variation in Leaves of Mulberry Trees," *Biometrica*, **1**: 258, 1902.

[13] Masters, M. T., "Vegetable Teratology," fig. 177. See also, Schlechtendal, *Bot. Zeit.*, **13**: 559, 1855, and Lloyd, *Torreya*, **2**: 137, 1902.

[14] Cushman, J. A., "Studies of Localized Stages of Growth in some Common New England Plants," AM. NAT., **36**: 865; *ibid.*, **37**: 243, **38**: 819.

[15] Jackson, R. T., "Localized Stages in Development in Plants and Animals," *Mem. Boston Soc. Nat. Hist.*, **5**^{4}: 89, 1899.

[16] Kerner von Marilaun, A., "The Natural History of Plants," **1**: 149; **2**: 569.

Trelease,[17] in a recent paper on his favorite agaves, says: "... my own conception of specific identities and differences in the genus oscillates as my study proceeds...."

While ultimately work of this nature, conscientiously carried out, leads to a clear delineation of the characters peculiar to each species, subspecies, variety, etc., there is reached, usually not so very long after the inception of the work and very long before its termination, a period of chaos which, to say the least, is the reverse of stimulating and ordinarily sufficient to dampen the ardor of the greatest enthusiast. Thus, in my cultures of local forms of *Capsella Bursa-pastoris,* the four forms described by Shull[18] and some of those of Almquist[19] can be recognized readily. But there remain so many whose classification is doubtful at the present time that it would cause Mr. Murdock, associated with me in this investigation, and myself to throw up our hands in despair, were it not for the fact that there have appeared in our cultures extreme forms, so striking and so different from any previously described, that we are inclined to believe we are possibly dealing with mutations in the sense of de Vries (Fig. 1). Research along these lines requires long and tedious experimental efforts. It is a different matter where the finding of distinctly new forms in an old territory is concerned. Here an element of chance largely enters. By increasing the number of our observations our chances of discovering something new may be increased materially. In other words, directly or vicariously a large amount of ground has to be covered. Yet I am not satisfied that a thorough knowledge of a comparatively small area would not lead to equally satisfactory results. The one requires about as much exertion as does the other and certainly the number of observations is identical. But the greater familiarity with the territory and the fact that observation may be continued throughout the seasons offers certain advantages. It is a question which must be decided for individual cases by every investigator along this line, since its answer must depend on local conditions, such as proximity to residence, climate, whether arid or temperate, etc. A garden, for instance, offers as good if not better opportunities to observe the appearance of new forms as does the field. Here all the requirements for such work are met with, *i. e.*, large numbers grown under highly favorable conditions. Parks, nurseries and especially the larger botanical gardens, where are kept accu-

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[17] Trelease, W., "Species in *Agave*," *Proc. Amer. Phil. Soc.*, **49**: 232, pl. 32, 33, 1910.

[18] Shull, G. H., "*Bursa Bursa-pastoris* and *Bursa Heegeri* Biotypes and Hybrids," Carn. Inst. Publ., No. 112, 1909.

[19] Almquist, E., "Studien ueber die *Capsella Bursa-pastoris* (L.)," *Acta Horti Berg.*, **4**, No. 6, 1907.

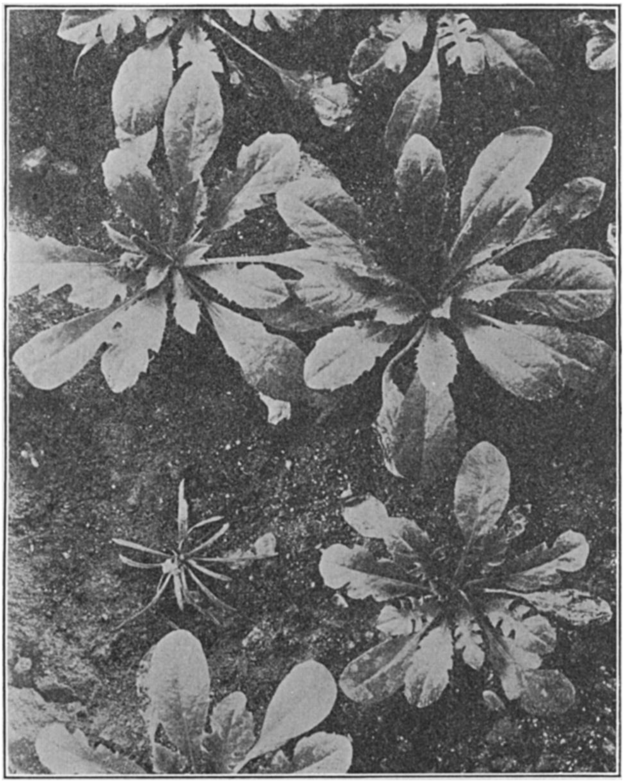

FIG. 1. Appearance of a new form among seedlings of *Capsella Bursa-pastoris*. × 1.

rate records of the histories of the various plants grown, constitute an important field. Thus, in the Missouri Botanical Garden, there are grown every year numerous plants of *Bellis perennis* "delicata." In 1906 the seed for these specimens was obtained from a Philadelphia seed firm. The seed was sown and the plants were handled in the usual manner until they finally found their way to the beds used for decorative purposes. It was while the plants, several thousands in number, were in this position, that the attention of Mr. Shelby Jones, at that time a student at the garden, was attracted to a plant because of the abnormal character of its flowers. In the capitula of this specimen the rayflowers had either disappeared, or, what is more probable, had been replaced by disc-flowers. The result was a rather striking, maroon-red button, in sharp contrast with the normal heads (Fig. 2). For in the normal form of the variety under cultivation the upper surface of the ligules was either white or rose-colored, while the lower surface was red. In the discoid variety, owing to the tubular nature of the transformed

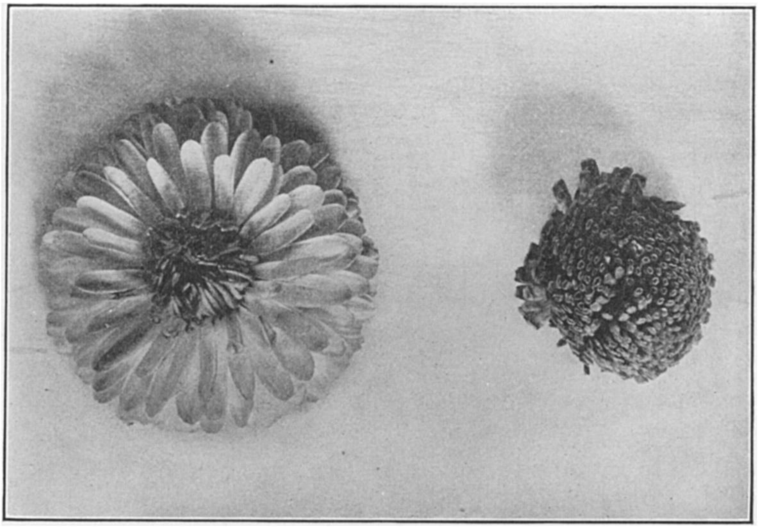

FIG. 2. Capitula of *Bellis perennis* "Delicata" and *Bellis perennis discoidea*. × 2.

rayflowers, the white coloring disappeared from view. It is an instance of change of color analogous to that of the cactus dahlia, though differing in one striking feature. For in the latter case the brilliancy of the flowers is due to the recurved rayflorets which show the bright color of the upper surface instead of the dull shade of the lower one, exposed to view in the older form of dahlia.

The plant was segregated and propagated vegetatively, as many as one hundred specimens being on hand at a time. Among these not a single instance of a return to the conventional form was observed. Of course, it would have been far more interesting to note the result of sexual propagation, a proceeding which was rendered impossible by the failure of the flowers to produce good seed. This, however, is quite in accordance with the experience of horticulturists, *fide* André.[20] In this most comprehensive publication the variety *discoidea* is mentioned under the name of "Paquerette vivace var. double a fleurs tuyautées," its slight fertility noted and attention called to the fact that the seed for such plants must be collected from flowers which are almost double. It is added: "leur tendance a doubler est assez bien fixée pour qu'on ne trouve dans le semis presque plus de fleurs de duplicature imparfaite." In this connection Master's notes published in the appendix to his "Vegetable Teratology," and de Vries's remarks on *Matthiola incana fl. pl.*[21] are of considerable interest. Penzig evidently refers to a similar form,[22] though his use of the term "ox-eye daisy" for this form appears to be contrary to usage, it being reserved ordinarily for *Chrysanthemum Leucanthemum*. Similar instances are not rare among Compositæ and are illustrated by *Matricaria* (*Chamomilla*) *discoidea* and *Anthemis tinctoria discoidea*. Very frequently one is able to find a few tubular flowers among the rayflowers of our cultivated composites, especially *Cosmos* and *Coreopsis*. Some of my earliest experiments, undertaken to study the effect of selection on such deviations, yielded negative results. De Vries[23] describes and illustrates a *fistulosa* variety of *Dahlia variabilis* which appeared among his cultures. Among chrysanthemums such "quilled" forms are not rare. "Enterprise" is a variety which illustrates this type and which not infrequently is met with at chrysanthemum exhibitions.

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[20] Vilmorin-Andrieux et Cie, "Les fleurs de pleine terre," 5th ed., R.-Ed. André, éditeur, 781, Paris, 1909.

[21] De Vries, H., "Plantbreeding," 238, Chicago, 1907.

[22] Penzig, O., "Pflanzen-teratologie," **2**: 59, Genoa, 1894.

Next to gardens, cultivated fields, *i. e.,* places where a large number of individuals of the same species or variety are grown, offer the best opportunity for the discovery of new or aberrant forms. One only has to be reminded of the case of the beardless Anderbeck oats.[24] In a similar manner there was found, among the numerous alfalfa plants which occupy a large portion of the acreage of the garden, a white-flowered specimen, the flowers of which, on fading, became almost yellow. Since then there were found in a neighboring field, a group of such white-flowered plants.

Color varieties are among the deviations most frequently noted, perhaps because the resulting change is particularly easy of observation. They occur both as to flowers, as for instance in *Lobelia syphilitica alba, Trifolium pratense album,* etc., and as to fruits, as instanced by *Gaylussacia resinosa leucocarpa,*[25] *Vaccinium pennsylvanicum leucocarpum, V. corymbosum atrococcum* f. *leucococcum, V. canadense chiococcum.*[26] White strawberries of course are well known. Yellow-fruited varieties exist of *Ilex myrtifolia*[27] as well as of *Ilex opaca* and *I. verticillata.* The Californian holly, *Heteromeles arbutifolia,* also has a yellow-berried variety.[28] *Calli-*

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[23] De Vries, H., "Mutationstheorie," **1**: 480, fig. 134.

[24] De Vries, H., *loc. cit.,* 59.

[25] Porter, Thos. C., "Additions to our Native Flora," *Bull. Torr. Bot. Cl.,* **16**: 21, 1889.

[26] Deane, W., "Albino Fruits of Vacciniums in New England," *Rhodora,* **3**: 263, 1901.

[27] Harper, R., "*Ilex myrtifolia* with Yellow Fruit," *Torreya,* **2**: 43, 1902.

[28] *The American Botanist,* **15**: 49, 1909.

carpa americana and *Rubus cuneifolius* both possess white-fruited varieties.[29]

Of *Solanum nigrum* there exist, besides the black-fruited form, one with yellow and one with green fruit. *Atropa Belladonna* exhibits the same color forms of the fruit which to us are familiar in the cultivated peppers, viz., red and yellow. Finally, in shrubs which are grown chiefly because of the coloring of the bark, for instance *Cornus stolonifera,* with a red bark, there may be met with forms which have a yellow bark. So numerous are references to color varieties in our literature and these variations are met with so often that their frequency suggests facility of origin perhaps parallelled only by that through which dwarf forms are produced. For several years, on collecting trips in the vicinity of St. Louis, Mo., all patches of *Lobelia cardinalis* were examined with particular care for white-flowered plants, since they were known to exist in various parts of the United States. Though these observations did not lead to the desired result, Mr. O. S. Ledman, of St. Louis, was able to find on the peninsula in the northern portion of Pittsburg Lake, St. Clair Co., Ill., opposite St. Louis and in a locality with which I believed myself to be thoroughly familiar and had searched most carefully on several occasions, some plants of *Lobelia cardinalis alba.*

This would indicate that the formation of the white-flowered variety had taken place recently, though the possibility of transportation from other localities, though improbable, is not excluded. That a white-flowered form of *Medicago sativa* is formed as readily seems likely. Various species belonging to the Leguminosæ possess *alba* varieties. De Candolle speaks of a color variety,[30] and at first it was thought the specimens under consideration could be classed here. Since then, however, there were found in the same alfalfa field several plants which answer the description of the variety mentioned in the *Prodromus,* more or less. It is more than probable that these plants, the flowers of which exhibit a great variation in color, are to be included under the "variegated alfalfas," for which Westgate[31] suggests the designation "*Medicago falcata* × (*M. sativa*), to indicate that "the hybrids have been recrossed several times with ordinary alfalfa and also among themselves." Hybridization, however, does not explain the white color of the flowers. That white-flowered plants and those with flowers of a yellow or cream color are not of rare occurrence is shown by the data furnished by Westgate[32] who notes such plants among four, respectively five of the forms experimented with. On the other hand, in view of the known existence of white-flowered forms the assumption of the formation of the white-flowered plants at Ann Arbor, through recent mutation, does not seem warranted. At the same time, such a possibility is not excluded, for while we do not believe that hybridization can have as its direct result the production of a new character, or the loss of one,[33] it is not at all improbable that hybridization indirectly may cause a plant to initiate a mutation period. It is expected that the seed gathered from the white-flowered plants will, in the course of a generation or two, yield a pure white offspring. This seems to be the experience of others. Mr. C. V. Piper, of the Bureau of Plant Industry, U. S. D. A., in a reply to a recent letter concerning *alba* varieties of *Medicago sativa* says: "Some of our selections of these white-flowered forms now breed true.''

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[29] Rolfs, P. H., "Variation from the Normal," *Asa Gray Bull.,* **8**: 75, 1900.

[30] *Medicago sativa versicolor* (Sér. mss.): floribus luteis coeruleisque. *M. falcata versicolor* Wallr. sched. cort., p. 398. *M. lutea-cærulea* hort., *Prod.,* **2**: 173, 1825.

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[31] Westgate, J. M., "Variegated Alfalfa," U. S. D. A., B. P. I., Bull. No. 169, February, 1910.

[32] *Loc. cit.*, 37, Table I.

[33] Instances which may suggest themselves but which obviously fall outside our definition, are in the first place those in which atavism comes into play, such as is the case in a cross between *Datura lævis* and *D. ferox.* (Naudin, *Ann. Sc. nat.*, 5 Sér., **3**: 155, 1865. Reciprocal crosses of the two white-flowered plants yielded a uniform offspring with pale purple flowers. (See also de Vries, "Mutationstheorie," **2**: 44, 201.) More recently, through the work of Cuénot, Durham and Nilsson, another, more plausible, explanation of the reappearance of the purple color can be given. (See L. Plate, "Vererbungslehre und Deszendenztheorie," 1910.)

In connection with this *alba* form I wish to call attention to the local distribution of a white-flowered form of *Solanum Dulcamara,* lately taken into cultivation in the experiment garden. This variety occurs but rarely in the vicinity of Ann Arbor, chiefly on river and lake shores and in swampy places. But at Albion, Mich., it was found in great abundance, growing in moist situations alongside of the species. While it will take some years to determine the constancy of this variety, there is in my mind no question as to the outcome of the experiment. It is a variety not always recognized in our floras, though evidently met with from time to time.[34] But if we give specific rank to mere color varieties, as we do in the case of *Datura Tatula* and *Datura Stramonium,* why not give taxonomic recognition to the equivalent color variety of *Solanum Dulcamara,* the more so

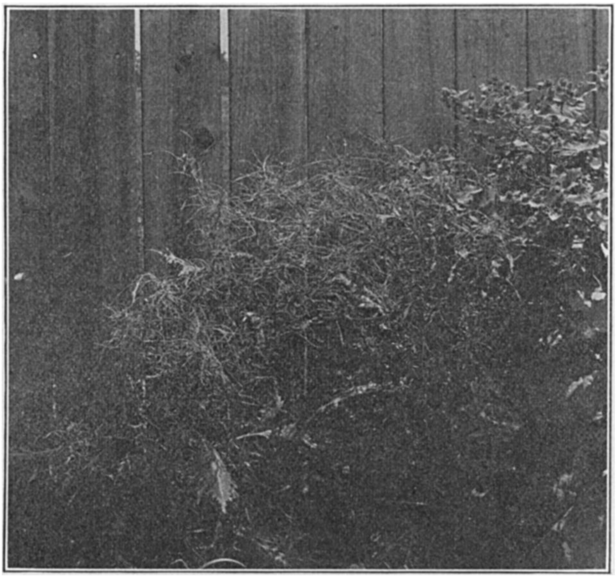

FIG. 3. *Arctium minus laciniatum* at Albion, Mich.

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[34] Collins, F. S., ''A Variety of *Solanum* New to America,'' *Rhodora,* **12**: 40, 1910.

since the addition of such an exceedingly variable character as is pubescence, seems sufficient to bring this about (*Solanum Dulcamara* var. *villosissimum* Desv.)?

The last illustration points to the largest source of new or at least imperfectly known species and varieties, *i. e.*, the native flora. The same rule applies here as in cultivated fields: striking morphological differences most readily attract attention. When the plant normally is possessed of large leaves, as is, for instance, *Arctium minus*, any differences in the foliage become especially noticeable. It is through this fortunate circumstance that we owe to Professor Charles E. Barr, of Albion College, Michigan, the discovery of at least a new locality for the apparently rare laciniate form of the species just mentioned (Fig. 3).

Laciniate forms are of relatively frequent occurrence. We find them not only among the phanerogams and the vascular cryptogams, but even among the algæ one can meet with forms which may be interpreted as such, for instance *Callophyllis furcata* Farlow[35] and *C. furcata* f. *dissecta* Farlow[36] (Fig. 4), though of course there is no connection. One of the earliest accounts of the sudden appearance of a laciniate variety is given by Marchant.[37] In 1715, in his garden, he discovered a plant which, though evidently belonging to the genus *Mercurialis*, was entirely new to him and which did not appear to have been described previously. He named it *Mercurialis foliis capillaceis*. No seed being collected, the next year the same garden spot was anxiously watched. Six plants made their appearance, four of which possessed the character of the plants which had appeared in 1715. The other two were sufficiently different to be segre-

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[35] Exsic. in Collins, Holden and Setchell, Phycotheca Bor. Am. Fasc. 18, No. 883, 1901.

[36] Setchell, W. A., and Gardner, N. L., ''Algæ of Northwestern America,'' 306, Univ. Calif. Publ., **1**, 1903.

[37] Marchant, J., ''Sur la production de nouvelles espèces de plantes,'' *Hist. de l'Acad. d. Sc.*, 1719, 57, Paris, 1721.

Marchant, J., ''Observations sur la nature des plantes,'' *Mém. de l'Acad. Roy. d. Sc.*, 1719, 59, pl. 6, 7, Paris, 1721. See also THE AMERICAN NATURALIST, **45**: 493, August, 1911.

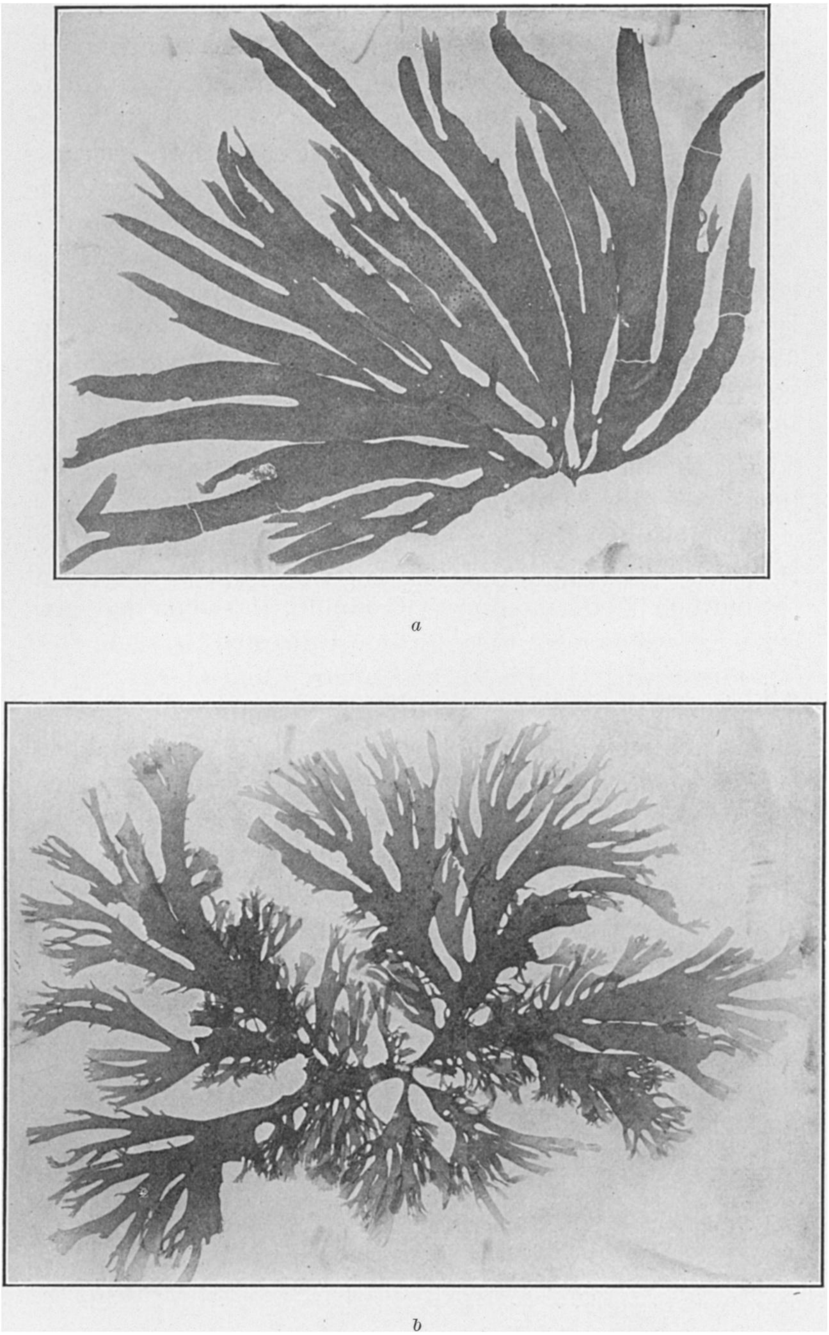

FIG. 4. *Callophyllis furcata* and *C. furcata dissecta.*

gated under the term *Mercurialis foliis in varias et inæquales lacinias quasi dilaceratis.* They were remarkable chiefly because of their laciniate leaves. Both forms appeared to differ from *Mercurialis annua* in having a longer lease of life, since they remained green until the latter part of December. Plants of both continued to appear in 1717 and 1718, propagating themselves.

Masters and others have given lists containing several instances of the appearance of laciniate forms, to whose number one readily may add by glancing over the catalogues annually published by the principal seed houses. It is especially of trees and shrubs (*Acer platanoides laciniatum, Betula pendula* var. *dalecarlia,*[38] *Rubus fruticosus laciniatus*) that cut-leaved varieties are in demand. This popularity is equaled only by that which *Chelidonium majus laciniatum* appears to enjoy in the world scientific, dating from the time when Roze[39] called attention to its history. Laciniation seems to have taken place at least twice in the genus *Chelidonium.* Of *C. japonicum* Thumb. occurs a var. *dissecta.*[40]

There exist several varieties of *Chelidonium majus.* Thus we have the broad-petaled form (*C. majus latipetalum*) of the Groningen Botanic Garden, the double-flowered variety and the cut-leaved one, the latter particularly interesting because the laciniation extends to the petals. During the last four years I have cultivated eight lots of *Chelidonium majus laciniatum,* two of which have double flowers, the seed being obtained through the exchange lists of various botanic gardens. These eight lots apparently represent five distinct forms. The differences are not great and probably would remain unnoticed by the casual observer. After constant association with them one can not fail to recognize the differences, however slight. But though slight, the differences are constant. They consist in the degree of laciniation as well as in degree of hirsuteness. It might be argued that these differences perhaps are due to differences in external conditions or in the age of the plants or in seasons, etc., just as the leaves produced by *Acer saccharinum* var. *Wieri,* in the latter part of the summer at the extremities of the long, slender twigs, have a lamina far more reduced than those formed earlier in the year. Roze calls attention to the fact that in his cultures of *Chelidonium laciniatum* the degree of laciniation of the leaves increased as the season advanced,[41] the petals undergoing a similar change. He also noted that the degree of laciniation increased with the amount of light received.

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[38] A cut-leaved variety of *B. pendula* is also known, *vide* Sanford, S., ''A Cut-leaved Cherry Birch,'' *Rhodora,* **4**: 83, 1902.

[39] Roze, E., ''Le *Chelidonium laciniatum* Miller,'' *Journ. de Bot.,* **9**: 296, 301, 338, 1895.

[40] Prain, D., ''A Revision of the Genus *Chelidonium,*'' *Bull. Herb. Boiss.,* **3**: 570, 1895.

The Papaveraceæ yield other instances of the reappearance of an abnormality in members of the same genus, for instance pistillody of the stamens. The most quoted instance is that of *Papaver somniferum polycephalum,* a variety which was grown more than fifty years ago in the trial grounds of the Vilmorins. Similar varieties were described by von Mohl for *P. orientale* and by Elkan for *P. dubium* (Henri van Heurck, ''Notice sur une prolification axillaire floripare du *Papaver setigerum,*'' *Bull. Soc. Roy. Bot. Belg.,* **2**: 329, 1863) and is said to occur also in *Macleya cordata* (Le Sourd-Dussiples et Georges Bergeron, ''Note sur un cas de métamorphose ascendante,'' *Bull. de la Soc. bot. de France,* **8**: 348, 1861).

While we have noted that the differences between the varieties are most marked in the early part of the year, the fact that our cultures were carried out under uniform conditions as to soil, light and water supply, and that the various types are recognizable even in the late summer, seems to indicate that these forms are entitled to varietal rank. The specimen illustrated in Fig. 5 ought to set at rest all doubts upon this point. One hardly would care to account for the extreme reduction of leaf surface in this case on the basis of the influence of fluctuating variability. This form, in all probability, is identical with the *Chelidonium majus foliis et flore minutissime laciniatis* of the Hortus regius (1661), which originated in the Paris Botanical Garden from seed of *Chelidonium majus laciniatum* and to which de Candolle afterwards gave the name *C. laciniatum fumariæfolium.*[42]

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[41] Roze, *loc. cit.,* 339. "... si l'on suit la plante dans sa croissance, on remarque que les deux ou trois premières feuilles (après les feuilles germinatives) ont l'apparence de celles de la forme *crenatum* et les dernières celles de la forme *fumarifolium,* mais a découpures plus courtes et moins étroites."

A second plant in our garden represents an extreme in another direction and is intermediate between the species and the variety *laciniatum.* It probably is identical with the var. *crenatum.*[43] Besides these three varieties I believe to be able to distinguish two other forms, constant from seed. It is possible that all of them originated through mutation of *C. majus laciniatum,* as did the variety *fumariæfolium.* It is equally possible that laciniate forms of *Chelidonium majus* have originated

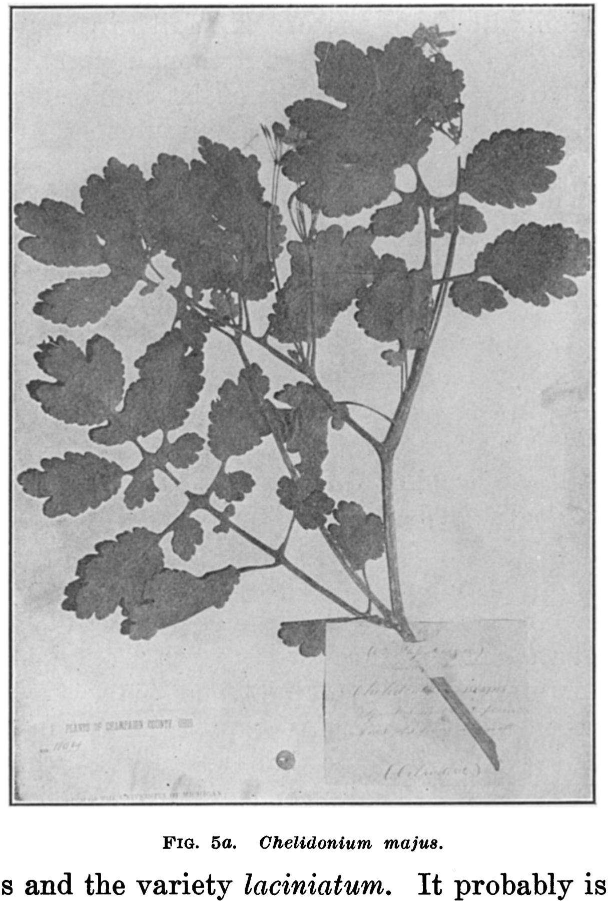

FIG. 5*a*. *Chelidonium majus.*

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[42] *Prod.,* 1: 123.

[43] *C. majus crenatum* Lange, Fl. dan.

more than once and directly from the parent species. This is the view taken by Clos,[44] who describes the finding by P. Barthès of a plant of *C. majus fumariæfolium* in Sorèze, Tarn. It is to be noted that these plants bore underdeveloped, seedless pods. This last seems to speak in favor of the assumption of a *creatio de novo,* since plants from other stock appear fertile. To this extremely interesting point, a discussion of which falls outside the scope of the present paper, I hope to return in an article shortly to be published.

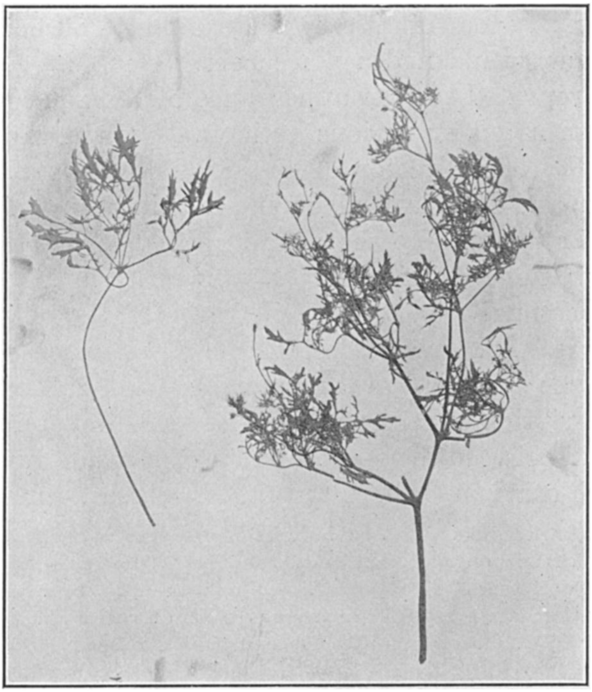

FIG. 5*b*. *C. fumariæfolium.*

The correctness of the view that the same mutation or at least a mutation in the same general direction may take place in different stocks, must be granted *a priori.* Evidence in the support of this belief we find in the existence of several distinct laciniate forms of different species of trees and shrubs. The varieties *heterophylla, laciniata, asplenifolia*[45] and *incisa* of *Fagus sylvatica, Alnus glutinosa laciniata, A. glutinosa quercifolia* and *A. glutinosa oxyacanthifolia* are instances to which numerous others might be added. It would seem that the laciniate forms of *Mercurialis annua,* observed by Marchant, would find a place here.[46]

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[44] Clos, D., "Réapparition de la Chélidoine a feuille de Fumeterre," *Compt. rend.*, **115**: 381, Paris, 1892.

The repeated sudden appearance of the same variety has been noted by various authors. Darwin, Korschinsky,[47] the late director of the St. Petersburg Botanic Garden, and de Vries[48] give numerous instances. Thiselton Dyer was able to show the repeated formation of at least two new varieties of *Cyclamen latifolium.*[49] Many, from personal experience, will be able to supply other instances. And while most of the cases which come to our notice probably are explainable through accidental transportation of seed or through Mendelian splitting of a hybrid between the species and a retrograde variety or through atavism,[50] there are others which do not admit of such an interpretation. Thus the finding by Mr. W. H. Ransome, of several plants of the four-leaved variety of *Fragaria vesca* at a point about twenty miles west of Kalispel, Flathead Co., Mont. A new form, which has appeared at various times and which because of the nature of the variation is incapacitated from reproducing itself by seed, would from this very fact constitute an ideal illustration of repeated mutation, since a hybrid origin of the individuals which appeared later, is excluded. Such an instance is yielded by the wheat-ear carnation, *Dianthus Caryophyllus imbricatus*. A sterile variety, it is propagated vegetatively. First described in the eighteenth century, and since then the subject of comment on the part of several teratologists, its sudden appearance has been noted in different stocks and at various times and places.[51] Instances of similar malformations may be met with from time to time. Thus Ballard[52] describes a sunflower in which the flowers were replaced by scales.

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[45] This variety, like cut-leaved varieties of other species, not infrequently shows atavism in certain shoots. See de Vries, "Atavismus durch Samen und durch Knospen" ("Mutationstheorie," **1**: 482), and also R. G. Leavitt, "Partial Reversion in Leaves of the Fern-leaved Beech," *Rhodora,* **6**: 45, 1904; O. Paulsen, "Blivende Axelblade hos Boegen," *Bot. Tidskr.,* **24**: 281, 1902; A. Trotter, "Contributo alla teratologia vegetale," *R. S. Bot.,* Italy, **44**, 1902.

[46] This variation in the degree of laciniation within a single species ought to throw some light on "unit-characters." If we consider—as I believe generally is done—laciniation to be a "unit-character" it would seem that such a "unit-character" may be subject to considerable variation, though the degree of variation is constant or at least approximately so for each individual case. This relative stability of the varietal character of course does not prevent the extremes of each degree of variation from overlapping.

[47] Korschinsky, S., "Heterogenesis und Evolution," *Flora,* **89**, 240, 1901.

[48] "Species and Varieties," 627.

[49] Thiselton Dyer, W. T., "The Cultural Evolution of *Cyclamen latifolium,*" *Proc. Roy. Soc.,* **61**: 135, 1897. See also J. Denman, "The Sporting Peculiarity of the Persian Cyclamen," *Gard. Chron.,* 3d Ser., **29**: 266, 1900.

[50] Among the plants cultivated in the experimental grounds of D. M. Ferry & Co., of Detroit, Mich., is a variety of cabbage bearing the name

It is a question whether the plants of *Arctium minus laciniatum* from Albion are to be considered as derived from preexisting plants of the variety or whether they have arisen *de novo*. Are they perhaps the result of a mutation of *Arctium minus?* Plants of both the species and the variety were found growing near the junction of Hannah St., Albion and the Kalamazoo River. The road at this point is bordered by a tall fence between which and the sidewalk is a space about 1½ feet in width. In a strip about 45 feet in length, among other weeds and with several specimens of the species, were found about a dozen individuals of *Arctium minus laciniatum*. Five of these were two-year-old plants, the remainder young rosets. As far as could be judged at the time, but slight differences exist between the leaves of the rosettes of the species and of those of the variety. A slight tendency

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''Early Winnigstadt.'' For the last eight or ten years from one to three per cent. of ''Green Glazed'' have appeared among them.

[51] De Vries, H., ''Species and Varieties,'' 228, 1905.

[52] *Gard. Chron.*, 3d Ser., **30**: 347, 1901.

to laciniation is all that could be observed. Perhaps the result of the cultural experiments, when a large number of rosettes can come under observation, will shed more light upon this point. But there was no danger of confusing the adult plants of the species and of the laciniate variety, for the latter presented a most striking appearance (Fig. 3). At first glance it seemed as if caterpillars or grasshoppers had destroyed the greater part of each leaf; the midrib and larger veins and here and there a small portion of the blade being left. A closer examination revealed the fact that the rosette leaves differed least from those of the normal plant. The leaves *a* and *b* in Fig. 6 show this sufficiently. The latter represents a rosette leaf of the var. *laciniata,* the former one of the species. The next leaves possess a marked laciniation (Fig. 6 *c, d,* etc.). As one proceeds higher up the stem, the laciniation becomes more pronounced, till finally but a figment is left of the leaves in the region of the inflores-

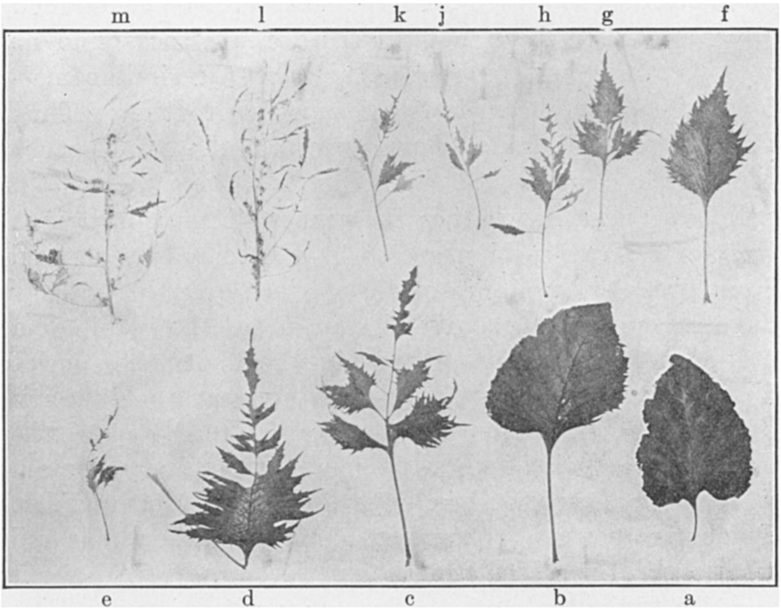

FIG. 6. *Arctium minus* and *A. minus laciniatum.* *a,* rose leaf of the species; *b-k,* leaves of the variety; *l, m,* inflorescences of the variety.

cence. In fact, there are leaves which possess a midrib only.

What appears to have been the same plant has been described in a recent publication,[53] as occurring in two different places about Joliet, Ill., and near Champaign, Ill. Here the inflorescence is referred to as "irregular with numerous small sterile flowers." It is also reported from South Bend, Ind.[54] Previously its appearance had been noted near Jessup, Ind.[55] Here also the inflorescence is described as "irregular, heads numerous, mostly small, rudimentary and apparently sterile." From an article by Fernald and Wiegand[56] it is gathered that Darlington in his "Flora Cestrica" referred to a similar plant.[57]

To Professor Fernald, who saw Darlington's specimen in the Gray Herbarium, I am indebted for the following: "Darlington's sheet bears the note: var. foliis pinnatifidis vel potius grosse dentatus. West Chester, Pa., August 25, 1858. These are imperfect specimens of the plant referred to in Fl. Cestrica, p. 156; but I am not sure that it is the one spoken of in Gray's Manual. The inflorescence always has a kind of half-starved or semi-abortive appearance. W. D."

The general appearance of the inflorescence certainly suggests a teratological development, giving an impression similar to that caused by inflorescences of *Rhus glabra* infested with a certain gall. But an examination of the living plants, at least such was the case with those at Albion, at once does away with any question as to their normal condition. The peculiar ragged appearance of the flowering shoots is merely due to a progressive laciniation as the leaves approach the apex, comparable to the seasonal reduction of the blades in *Acer saccharinum* var. *Wieri,* or of the various laciniate varieties of *Chelidonium majus* referred to above. Also, Professor Barr was able to gather seed. It should be stated in this connection that while the seed of the species, obtained from Albion, germinated readily and produced typical *Arctium* seedlings, there appeared in the seedpans devoted to the variety, seedlings having all the characteristics of those of *Lactuca Scariola integrata,* and these only. Seedlings of species and their varieties are as a rule so much alike that the thought at once presented itself that some seed of the wild lettuce either had become mixed with the seed of the variety or was contained in the soil used for growing the seedlings. Were either of these suppositions correct, it would seem curious that the same thing had not occurred in the case of the seed of the species. At least one of these possibilities could have been eliminated had it been possible to sow the seed in sterilized soil. As the rosettes grow older there could be no doubt as to their really belonging to *Lactuca.* While therefore these experiments yielded negative results, it still is possible that their repetition, with perhaps certain modifications, may result differently. Also an attempt should be made to obtain seed from a different source, for it is very well possible that while one lot of laciniate-leaved plants is fertile, another, perhaps of distinct origin, is sterile. We find an analogy in the case of *Chelidonium majus laciniatum* quoted above.

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[53] *The American Botanist,* **15**: 83, 1909.

[54] *The American Botanist,* **15**: 112, 1909.

[55] Brown, H. B., "A Peculiar Specimen of *Arctium,*" *Plant World,* **12**: 135, fig. 2, 1909.

[56] Fernald, M. L., and Wiegand, K. M., "A Synopsis of the Species of *Arctium* in North America," *Rhodora,* **12**: 43, 1910.

[57] Darlington, W., "Flora Cestrica," 436, 1837. "A variety has been observed here, occasionally, with pinnatifid leaves." Perhaps the references to a variety with pinnatifid leaves met with in Wood's Flora and in the earlier editions of Gray's "Manual" owe their origin to this note.

Unfortunately but few herbarium specimens are available for comparison with the specimen of Darlington in the Gray Herbarium. Through the courtesy of the curators of the herbaria mentioned we learn that in the herbarium of the Smithsonian Institution the variety is represented by a single specimen "collected by Alfred E. Ricksecker at Elyria, Lorain County, Ohio, August 1, 1894." It is added that it has very deeply laciniate leaves and that the venation is very different from that of the common form. In both these respects it agrees with the Albion specimens.

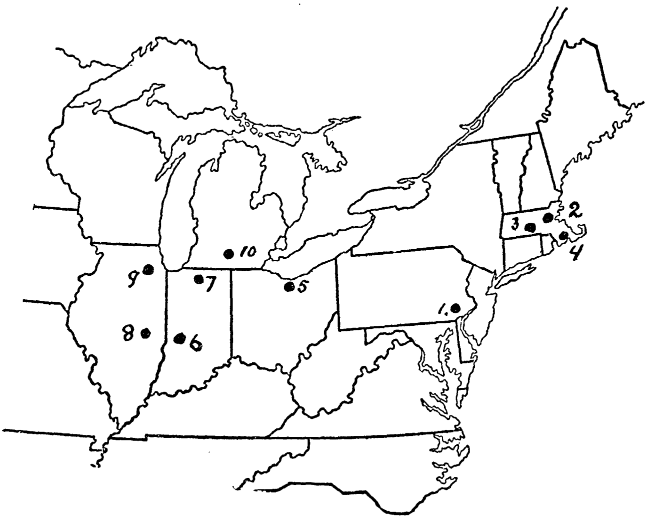
From the herbarium of the New York Botanical Garden, Dr. Marshall A. Howe was kind enough to write: ''We have in our herbarium apparently only one specimen of the form that you have in mind.'' This specimen was collected in 1865 at Uxbridge, Mass., by J. W. Robbins. Another sheet of this material is in the Gray Herbarium.

Through the courtesy of Professor William Trelease we know that a laciniate-leaved variety of the burdock is represented in the herbarium of the Missouri Botanical Garden by two herbarium sheets, the one, without date, bearing a specimen collected in Europe, the other a specimen collected at New Bedford, Mass., in 1890 by Harvey. Professor Trelease adds: ''Neither has represented the extreme cutting of the leaves that yours shows, but there is enough of it to lead me to think that as extreme forms might have been collected.''

Dr. Greenman, of the Field Museum of Natural History, fails to identify any material in this collection with *A. minus laciniatum*, ''unless possibly a very poor specimen collected at Chelsea, Mass., Sept. 24, 1863, by J. Blake.''

While it is probable that the same form occurs in Europe, thus far it does not appear to have been recorded in the floras. Inquiries on the part of my friend Dr. Jongmans, of the State Herbarium at Leyden, Holland, failed to elicit confirmatory answers, nor does the variety appear to be represented either in the Leyden herbarium nor in any of the European herbaria whose curators I have been able to consult.

It is hoped to amplify, by further inquiries, these somewhat meager data. From what we know at the present time, it would appear that *Arctium minus laciniatum* is of comparatively rare occurrence (Fig. 7). I have never met it except at Albion, though a good deal of territory was covered both here and abroad and I was looking for just such variations. Professor Barr, who has botanized extensively in the vicinity of Albion, never has encountered it. From a glance at the map it appears not improbable that this plant, perhaps having its origin in Massachusetts, or introduced there from Europe, perhaps in ballast, gradually has been transported to various points of the compass, the area being covered by it being limited to the northeastern section of the United States. The transportation of seed, provided this is formed at all, is not unlikely. Fairly large gaps, though, appear between certain of the dates of collection. Thus, the plant does not appear to have been collected between 1837 and 1858, between 1865 and 1890, between 1894 and 1907, gaps, respectively, of eleven, fifteen and thirteen years. Yet these lacunæ very well may be accounted for on the one hand by the failure of botanists to collect the



Distribution of *Arctium minus laciniatum.*

FIG. 7. Map, showing successive collection of *Arctium minus laciniatum* in the United States, 1837–1910, and based upon the data available at the present time.

1.	Chester Co., Pa.	1837	6.	Jessup, Ind.	1907
	West Chester, Pa.	1858	7.	South Bend, Ind.	1909?
2.	Chelsey, Mass.	1863	8.	Joliet, Ill.	1909
3.	Uxbridge, Mass.	1865	9.	Champaign, Ill.	1909
4.	New Bedford, Mass.	1890	10.	Albion, Mich.	1910
5.	Elyria, Ohio	1894			

"abnormal" specimen and on the other hand by the lack of data at our command.

There will not be wanting those who are inclined to look upon the Albion specimens as well as upon those from other localities as having originated through mutation. The mutation idea, however, involves the idea of constancy. Will the laciniate form come true to seed? If the laciniate plants at Albion are mutants one ought to be able to get a certain percentage of laciniate plants from the apparently normal plants in the same locality, eliminating in the experiment all possibility of hybrid origin. Experiments to determine this have been inaugurated, but at least four or five years must elapse before their results can be communicated. In view of our experience with other laciniate forms and provided the variety produces good seed, the question can hardly be answered in the negative, though in view of the opinions expressed by others we must reserve our decision until the question has been answered by the plant itself. For this is, after all, the only method which, though perhaps tedious at times, will lead to a sane and safe conclusion. Those in sympathy with this idea realize one need not go far from home to find material as abundant, as interesting, as instructive, as important, as can be met with at a greater distance. And while the exploration of new or difficultly accessible regions offers many attractions, he to whom such an opportunity is not given need not feel slighted, for work nearer home offers the advantage of greater facility, especially of observation. Working along lines similar to those followed by de Vries, Veit Wittrock, Dahlstedt and Nillson, it is to the botanic garden we must look for a solution of our problems.